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UNITED STATES DEPARTMENT OF AGRICULTURE
BULLETIN No. 728

Contribution from the Bureau of Plant Industry
WM. A. TAYLOR, Chief

Washington, D. C. ▼ December 18, 1918

CERTAIN DESERT PLANTS AS EMERGENCY STOCK FEED

By

E. O. WOOTON, Agriculturist

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THE NECESSITY FOR EMERGENCY FEEDS.

It has been the practice for a long time in certain parts of the arid Southwest, mostly in what is known as the Big Bend region of southern Texas, to feed sotol[1] to range stock in seasons of scarcity of the usual range feed. The custom is probably one that originated in Mexico, where this plant is used more or less extensively for human food, as well as for the production of an alcoholic beverage where, consequently, its qualities are well known.

Hitherto, the usual method of preparing sotol for stock feed has been to cut the stem off at the ground and with a machete or an ax split open the head, which is formed of the enlarged leaf bases and the thickened top of the stem. This process exposes the soft tissue of the head to the animals, and either cattle or sheep may be expected to "do the rest."

The past two seasons, 1916 and 1917, have been unusually dry in the whole of the arid Southwest from central Texas to the Pacific coast, and in consequence the normal crop of range feed did not grow. Farsighted stockmen in many cases sold off some of their

[1] Sotol is a Mexican or Indian name for a species of Dasylirion. The species found in western Texas is *Dasylirion teranum*, while the plant of southern New Mexico and Arizona is *D. wheeleri*. See descriptions of species farther on in this bulletin.

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animals or moved them to other places, in order to reduce the number to be kept on their ranges to something like a proper adjustment of the numbers to the feed available. Many have fed prickly pear [1] with success when any of this kind of feed was present on their lands.

Notwithstanding the recognized necessity for a reduction in the numbers of animals upon the range, there were many men who for one reason or another were unable to sell or move their animals. Under such circumstances the only possible alternatives were to feed the animals or let them die.

The idea of feeding range stock is not new to most of the stockmen in western Texas and in southern California, but for the men in southern New Mexico and southern Arizona, who are almost without exception cattlemen, the practice is largely a new one, though many of them have heard of the use of sotol as forage, and some who have lived in Texas have practiced feeding it. Sotol occurs in only a very small part of the country where feed was scarce this past year, but in much of this area there is a greater or less amount of other species of plants that are usable.

Stimulated by the patriotic desire to avoid all possible losses of meat animals as well as probable serious financial loss, the more enterprising men began casting about for feed of one kind or another. Many of the men in Texas had already laid in a supply of cottonseed cake or meal. Some were able to buy milo maize, or kafir corn, or hay of some kind. But the supply of many of these feeds was below normal for the region because of the drought, and all were abnormally expensive, while transportation systems were much overworked. Hence the need of using all kinds of feed available on the ranges.

It is difficult to determine just who should be credited with the idea of using certain of the plants other than sotol that grow abundantly in some places in the region. The practice seems to have arisen independently in several places at about the same time, both in Arizona and in New Mexico.

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[1] Griffiths, David. Behavior, under cultural conditions, of species of cacti known as Opuntia. U. S. Dept. Agr. Bul. 31, 24 p.., 8 pl. 1913.

——— Feeding prickly pear to stock in Texas. U. S. Dept. Agr., Bur. Animal Indus. Bul. 91, 23 p., 3 pl. 1906.

——— The prickly pear and other cacti as food for stock. U. S. Dept. Agr., Bur. Plant Indus. Bul. 74, 46 p., 5 pl. 1905.

——— The prickly pear as a farm crop. U. S. Dept. Agr., Bur. Plant Indus. Bul. 124, 37 p., 2 pl. 1908.

——— The "spineless" prickly pears. U. S. Dept. Agr., Bur. Plant Indus. Bul. 140, 24 p., 1 fig., 1 pl. 1909.

——— The thornless prickly pears. U. S. Dept. Agr., Farmers' Bul. 483, 20 p., 4 fig. 1912.

——— Yields of native prickly pear in southern Texas. U. S. Dept. Agr. Bul. 208, 11 p., 2 pl. 1915.

——— and Hare, R. F. Prickly pear and other cacti as foods for stock. N. Mex. Agr. Exp. Sta. Bul. 60, 134 p. 1906. Literature, p. 124–125.

——— ——— Summary of recent investigations of the value of cacti as stock food. *In* U. S. Dept. Agr., Bur. Plant Indus. Bul. 102, p. 7–18, 1 pl. 1907.

Hare, R. F. Experiments on the digestibility of prickly pear by cattle. U. S. Dept. Agr., Bur. Animal Indus. Bul. 106, 38 p., 1 fig., 1 pl. 1908.

Thornber, J. J. Native cacti as emergency forage plants. *In* Ariz. Agr. Exp. Sta. Bul. 67, p. 457–508, 8 pl. 1911.

Wooton, E. O. Cacti in New Mexico. N. Mex. Agr. Exp. Sta. Bul. 78, 70 p., 18 pl. 1911.

The first suggestion of using any of these plants for feed, of which the present writer knows, was made to him in 1914 by Mr. C. T. Turney, of Mesilla Park, N. Mex. Mr. Turney's idea was to use the tops of a species of Yucca (*Yucca elata*) locally known as soap weed, for silage.[1] Mr. Turney was cooperating with the United States Department of Agriculture on the Jornada Range Reserve near Las Cruces, N. Mex., in handling more than 5,000 cattle under the range conditions of that region. It was here, in 1915, that the first controlled experiments in the feeding of chopped soap weed to range cattle were begun. Cutting up the tops with an ordinary silage cutter was found to be difficult, and the chopped material was not altogether satisfactory, because the machine used was too light for the work. Mr. Turney asked a firm of manufacturers at El Paso, Tex., for a heavier machine, which they proceeded to design and make. This machine[2] has been in use for some time in southern New Mexico and is the first of a number since made and now in use. It is heavy enough to cut up the stalks of the soap weed, and thus the discovery was made that the stalks are better feed than the tops.

In 1916 Messrs. Cook and Johnson, of Willcox, Ariz., fed this same plant, the material being chopped into pieces of suitable size by hand, the men using axes and hatchets. A number of animals were fed in this way, but the work entailed is very hard and the feed produced is not in a very good condition, though the results obtained were fairly satisfactory. Several of their near neighbors tried the plan. Most of these men have recently bought machines to do the work and are getting better results.

In May, 1917, a man at Thatcher, Ariz., devised and built a machine for slicing soap weed which was in use for a short time. Since then some modifications of this type of machine have been introduced which have materially improved its usefulness.

In January, 1918, a machinist at Deming, N. Mex., designed and constructed a machine which shreds the stalks of this same plant.

Besides these machines, the ordinary wood-pulping "hog," such as is used for cutting up wood for paper pulp, has been tried with some success.

It will thus be seen that many people appreciated the need of such machines and that stockmen have been eager to buy them and use them. Machines of various makes are now in use on ranches all the way from Willcox, Ariz., to Marathon, Tex., and north from the Mexican boundary to Carlsbad, Engle, and Silver City, N. Mex. Considerable extension of this area to the northward in eastern

[1] Jardine, J. T., and Hurtt, L. C. Increased cattle production on southwestern ranges. U. S. Dept. Agr. Bul. 588, p. 26. 1917.

[2] See the El Paso Morning Times of Jan. 7, 1918, for the story of this machine.

New Mexico may be expected as stockmen learn that a number of the desert plants may be used in this way and they equip their ranches with the machines.

THE MACHINES.

From what has been said, it is easy to see that the essential factor in the development of this use of an emergency feed was the production of apparatus that would reduce the feed to a satisfactory mechanical condition. While hand chopping will prepare the feed for use, it is a very unsatisfactory method, because the process is slow and laborious and consequently expensive and also because the feed as prepared in this way consists of chopped-up chunks of various sizes which a greedy animal may swallow whole without chewing and which may cause choking or impaction. A number of animals have died from these causes when fed on the hand-chopped material.

Among the stockmen who fed the hand-chopped material, one or two rigged up a power pumping jack with a knife attached in such a way as to cut the stalks into sections of proper size, which were then chopped into smaller pieces with hand axes. On one ranch, a large knife, like a tobacco-cutting knife, with a long lever operated by two men, was used to cut the stalks into sections ready for the hand axes.

A few silage cutters have been used successfully, though it is necessary to chop the stems open lengthwise (they have no longitudinal grain and therefore can not be split) before they will go through the machine.

Special power-driven machines, however, were necessary to prepare these plants in sufficient quantity to meet the requirements of the situation.

Four such machines are now offered for sale by three different manufacturing companies. These machines are all modifications of a single plan. They consist essentially of a heavy cast cylinder that revolves on a horizontal shaft and carries some kind of knives or cutting teeth that pass close to a chopping block to which the material is carried by some feeding mechanism or by gravity from a hopper.

In the largest machine the knives are like those on a silage cutter or a lawn mower. Each knife is slightly longer than the cylinder and is placed diagonally across and bent around the face of it, thus giving it a shearing cut as it passes the chopping block which is parallel to the shaft on which the cylinder revolves. The plants are fed in horizontally by a mechanism driven by gears from the cylinder shaft. (Pl. I, fig. 2.) A 12 to 14 horsepower gasoline engine can drive this machine without any trouble and, if properly managed, a crew of three men may be expected to chop from 15 to 20 tons of soap weed in a 10-hour day if the plants are brought to them.

FIG. 1.—AN EMERGENCY-FEED CUTTING MACHINE IN OPERATION ON THE Z BAR L RANCH.

FIG. 2.—AN EMERGENCY-FEED CUTTER IN OPERATION ON THE HIGH-LONESOME RANCH, NORTHWEST OF LORDSBURG, N. MEX.

FIG. 1.—THE CATTLE THAT WERE BEING FED CHOPPED SOAP WEED ON THE HIGH-LONESOME RANCH, NORTHWEST OF LORDSBURG, N. MEX.

FIG. 2.—A YUCCA AND SOTOL CHOPPER IN OPERATION ON MR. J. D. PREWITT'S RANCH AT BOWIE, ARIZ.

FIG. 1.—A CHARACTERISTIC STAND OF SOAP WEED (YUCCA ELATA) IN SOUTHERN NEW MEXICO.

The yield from such an area will average 2 to 2½ tons of fresh feed per acre, but a growth of 10 or 12 years will be necessary to produce another such crop.

FIG. 2.—A TYPICAL LARGE SOAP WEED (YUCCA ELATA) GROWING IN A DEEP SANDY SOIL SUCH AS IT PREFERS.

FIG. 1.—OLD SOAP WEED (YUCCA ELATA) NEAR THE ARIZONA LINE, NORTHWEST OF LORDSBURG, N. MEX.

These plants are 12 to 15 feet high exclusive of the flower stalks. They are at least 50 years old. Compare this figure with figure 2 of this plate.

FIG. 2.—MATURE BEAR-GRASS (YUCCA GLAUCA) NEAR ELIDA, N. MEX.

This figure and figure 1 bring out the similarities and differences between these two nearly related species so far as they can be seen in plants that are not in bloom.

FIG. 1.—THE BLOOM STALK OF SOAP WEED.

All the yuccas have flowers more or less resembling these. The individual flowers of Dasylirion and Nolina are less than one-fiftieth the size of these.

FIG 2.—A THICK PATCH OF SOTOL (DASYLIRION WHEELERI).

Plants in full bloom, on the foothills of the Dona Ana Mountains, N. Mex.

FIG. 1.—SPANISH BAYONET PLANTS GROWING NEAR VAIL, ARIZ.
To the left is a plant of sotol.

FIG. 2.—THE SPANISH BAYONET, OR PALMA (YUCCA MACROCARPA), NEAR STATE COLLEGE, N. MEX.

FIG. 1.—LECHUGUILLA (AGAVE LECHUGUILLA) GROWING ON LIMESTONE HILLS AT EL PASO, TEX.

FIG. 2.—THE SPANISH BAYONET, OR AMOLE (YUCCA BACCATA), IN FLOWER, SAN ANDREAS MOUNTAINS, N. MEX.

FIG. 1.—SACAHUISTA (NOLINA ERUMPENS) NEAR SONORA, TEX.

FIG. 2.—BEAR-GRASS (NOLINA MICROCARPA) IN THE SAN ANDREAS MOUNTAINS, 35 MILES NORTHEAST OF LAS CRUCES, N. MEX.

There are two machines in which the cutting is done by a set of small teeth screwed into the face of the cylinder and so arranged that each tooth strikes at a different time, all taken together cutting across the full width of the cylinder. Both these are modifications of the ordinary wood-pulping "hog," the essential differences being merely those of the size and shape of the teeth. These machines are smaller than the first one mentioned and require an engine of 6 to 8 horsepower to operate them satisfactorily, though both are actually being used with engines that furnish less power than this. They both shred the stalks of the soap weed into small pieces that cattle may eat freely without any danger of impaction. (Pl. II, fig. 2.) Each machine is fed by hand from a vertical hopper, the weight of the stalks helping to keep them against the teeth. The output from either of these machines running at about the rate which might be expected in practice is approximately 1 ton of chopped feed per hour.

The fourth machine has a set of triangular knives, something like the knives on the cutter bar of a mowing machine, bolted to the face of the cylinder, each knife being raised above the surface of the cylinder by a narrow triangular steel block about three-fourths of an inch thick, through which the bolts pass. These knives slice the stalk into sections one-half to three-fourths of an inch thick, cutting the fibers into short pieces. In its latest form the knives are diamond shaped and reversible, while the machine is fed from a troughlike hopper inclined at about 45°. In its earlier form this machine had a horizontal mechanical feed, but the makers have ceased to furnish this heavier and more expensive cutter. Machines of this kind may be expected to cut from 10 to 12 tons per day. This cutter has never received a distinctive name, but it is manufactured at Deming, N. Mex. (Pl. I, fig. 1.)

The earlier machines were constructed so they could be mounted with a gas engine on wheels and moved from place to place. Experience has shown that in most cases it is easier to set up the cutter at the corral and run it by the engine that pumps the water for the live stock. All the very poor cattle have to be fed at the watering place, because they are usually too weak to walk very far for water. The newer and smaller machines may be had with or without a frame for use on a wagon.

The Office of Forage-Crop Investigations of the Bureau of Plant Industry, United States Department of Agriculture, will be glad to answer any inquiries regarding machines and their manufacturers and to furnish any additional information in its possession regarding the use of desert plants as emergency stock feed.

The important conclusions to be drawn from the available data relative to each of these machines are (1) that they will do the work required of them; (2) that they are so constructed as to be operated easily by the kind of labor available; (3) that they may be had at

such prices as stockmen can well afford to pay for the work to be done; (4) that the power required for the work is such as is supplied by the kind and size of engine frequently found on the average stock ranch or which may be purchased at a reasonable price; and (5) that the use of these machines renders available a supply of low-grade feed which will save the lives of animals that would otherwise starve. (See Pl. II, fig. 1.)

KINDS OF FEED.

As has already been stated, the feeding of sotol is not new nor is the idea of using certain other plants that have either stems or leaves (or both) that are more or less thickened. All the development of the use of prickly-pear has come about from carrying out this idea with respect to certain cacti. It is one of the purposes of this bulletin to summarize as definitely as possible the available data as to possible sources of stock feed of this kind.

One difficulty to be overcome, which is a cause of considerable misunderstanding and frequent differences of opinion, arises from the confusion of the various common names in use for the different plants and the similarities in their appearance.

The plants which may be chopped up and used as emergency feed belong to two families, embracing 4 or 5 different genera and as many as 12 to 20 different species. Almost any one of them may be very easily confused with one or more of the others that are similar in appearance. Differences which are very easily seen to exist among the flowers and fruits, the basis of most botanical classifications (Pl. V, fig. 1), are not to be seen except in the flowering season, and most people have not examined them at that time. The differences in the leaves and habits of the plants by which they can be distinguished when the plants are not in bloom or in fruit are here described.

SOAP WEED.

In the region between Pecos, Tex., and Tucson, Ariz., and south of Safford or Clifton, Ariz., and Silver City and Socorro in New Mexico, on the sandy plains, occurs in greater or less abundance a narrow-leaved yucca that is usually referred to by the English-speaking population of the region as soap weed. It is one of the commoner, and frequently the commonest and most conspicuous, of the desert shrubs. It is often called amole or by its proper Mexican name of palmilla (the little palm), and in the region about Thatcher, Ariz., it is called ooce, which is probably an Indian name for it. This is one of the two commonest yuccas of a region where there are several, and is known botanically as *Yucca elata* (the tall yucca). (Pl. III, figs. 1 and 2; Pl. IV, fig. 1.) It is called soap weed and amole because its roots (and stems) are frequently used as a soap substitute. This name soap weed is not distinctive of any species, though most commonly applied to the one mentioned, but is often applied to other plants that

are used for this purpose. This confusion of usage explains how two people may disagree about certain peculiarities of soap weed; they are probably thinking and talking of two different plants.

OTHER THICK-LEAVED PLANTS.

The yuccas may be recognized when not in flower by characters which apply to all the species of the region except three. The leaves of all species are each tipped with a sharp spine, and the margin of the leaf bears one or more threadlike fibers which frequently strip back and form a loose mat of threads among the bases of the leaves. The margins of the leaves never bear any hooklike spines. In one group of three species that grow in the region of Del Rio, Sanderson, and northward in Texas the leaf margins do not have a threadlike appendage, but are thickened and horny, with very fine teeth, scarcely large enough to be seen by the naked eye, but sharp enough and hard enough to cut the hands badly.

Of the other thick-leaved plants of the region the century plants (Agave) all have sharp spines on the ends of the leaves, but the margins bear large recurved spines. Sotol (Dasylirion) has flat, strap-shaped leaves with curved, yellow, horny spines on the margin, but they are frayed at the tips. (Pl. V, fig. 2.) There are two or three species of Nolina in the region that have long, slim, nearly smooth, but tough leaves, frayed at the tips, without threads or spines, though sometimes a few very small teeth are scattered along the margin. The leaves of these plants are often as thick as they are wide, which is usually not much over one-fourth of an inch, being nearly always triangular, but sometimes nearly circular in cross section. In the region about Marathon and Sanderson, Tex., where one species (*Nolina erumpens*) [1] is tolerably abundant, the common name in use is sacahuista.[2] (Pl. VIII, fig. 1.)

BEAR-GRASS.

Bear-grass is a name that is used for two very different plants in different localities. On the Plains of eastern New Mexico and western Texas from Carlsbad northward to western Kansas and eastern Colorado, found practically always on the sandy land, the plant called bear-grass is a species of Yucca (*Y. glauca;* Pl. IV, fig. 2) that has many narrow, thin, thread-bearing leaves that are borne on a very short stem growing from a rather large root from which new heads of leaves arise whenever the old ones are cut off. The leaves are three-eighths of an inch wide or less, hardly more than one-sixteenth of an inch thick, and 18 to 30 inches long. The stem is usually not over 6 or 8 inches high. By using the same name for the two plants and failing to recognize their differences (which are not marked in plants

[1] The variety called *compacta* by Dr. Trelease is associated with the species throughout this region.

[2] This name is also applied to a species of Spartina, a coarse grass, in the coastal-plains region of Texas.

that are not in bloom) a few people are confusing this plant with the soap weed (*Yucca elata*) already described, and differences of opinion as to the length of time it will take these plants to grow a second crop are already arising in discussions of the future prospects of this kind of feed.

In southwestern New Mexico and adjacent parts of Arizona from Silver City and Clifton southward is an entirely different plant that is known as "bear-grass." (Pl. VIII, fig. 2.) It is a species of Nolina (*N. microcarpa*) and closely resembles the sacahuista of the Marathon, Tex., region. This plant nearly always occurs on the gravelly or rocky foothills, though it sometimes spreads out over the land that is more nearly level. It is common on the hills south of Silver City, N. Mex., abundant on both sides of the railroad at Dragoon, Ariz.,[1] and a large area covered with it is found in the south end of the Animas Valley in southwestern New Mexico. A scattering growth may be expected on the foothills of the mountains associated with sotol from the region of El Paso westward.

SPANISH BAYONET, OR DAGGER.

The name Spanish bayonet (or dagger) is applied pretty generally to several broad-leaved species of Yucca and some near allies. The Spanish word palma (palm) is also occasionally used for these plants. There are several species that are hard to distinguish without flowers and fruit. Some of them are illustrated in this bulletin (Pl. VI, figs. 1 and 2; Pl. VII, fig. 2).

LECHUGUILLA.

Lechuguilla is a Mexican name for a species of Agave[2] that is quite common in the Big Bend region of Texas, especially in Brewster and Presidio Counties, south of the Southern Pacific Railway (Pl. VII, fig. 1). This plant is used as a fiber plant in northern Mexico. Animals sometimes eat it during periods of drought, but stockmen of the region are afraid of impaction from the abundant and strong fibers it contains. The plant is said to be increasing in the region mentioned, and stockmen would be glad to see it driven out, since it kills out the grass and thus reduces the available feed. Its rigid brown and black spines terminating the stiff leaves and its habit of growing thickly all over the ground make land occupied by it almost impassible for cattle or horses. However, it is easily cut with a mattock, and the large cutter shown in Plate I, figure 2, chops it into pieces that stock can easily masticate. With the fiber cut in small pieces and most of the spines chopped off, this plant will furnish considerable emergency feed, and its removal from the range will favor the grasses. It is probable that it can be cut up by a lighter

[1] Trelease refers the plants about Dragoon and other places in eastern Arizona to *Nolina caudata* Treal.

[2] *Agave lechuguilla* Torr. Other species of this genus occur in the region under consideration, but never in sufficient quantity to be important as feed. They are generally known by the name of mescal or maguey.

machine, like a silage cutter, if the knives are kept sharp. The chemical analysis indicates that this material is of about the same feeding value as the other plants here discussed.

SOTOL.

Sotol[1] is the name applied to all species of Dasylirion in the Mexican border region, as well as in northern Mexico. In south-central Arizona it is sometimes called sotoli. These plants grow only on the rocky foothills of the mountains and part way up the mountain sides. They are easily recognized by their numerous long, flexible, strap-shaped leaves, bearing yellow curved spines on their margins. Over small areas they are sometimes very abundant, but such thick patches are not common.

KEYS TO PLANTS DESCRIBED.

For convenience in identifying the above-mentioned plants when not in bloom the following artificial keys may be used.[2]

Key to the genera.

I. Leaves tipped with a more or less rigid spine.

A. Margins of the leaves bearing a threadlike fiber or sometimes without the fiber but having a minutely toothed, horny margin.....1. YUCCA.

This genus contains the soap weed, one of the plants called bear-grass, the Spanish bayonet, etc.

B. Margins of the leaves bearing conspicuous recurved gray, brown, or black spines.....2. AGAVE.

This genus includes the century plants, lechuguilla, mescal, and maguey.

II. Leaves usually frayed at tip, never having a terminal spine.

C. Leaves thin and strap shaped, margins bearing small yellow curved spines.....3. DASYLIRION

The species of this genus are all called sotol.

D. Leaves narrow, usually nearly as thick as they are wide, margins smooth or very minutely and sparsely toothed, sometimes tapering into a long, slender, curved or bent tip.....4. NOLINA.

This includes the sacahuista and another plant called bear-grass.

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[1] The spelling is Spanish though the word may be Indian, and the accent is on the second syllable. The Americans are beginning to drop the "l," put the accent on the first syllable, and apply the word to the soap weed in the Deming to Bowie district where they are not very well acquainted with the real sotol.

[2] To determine the name of a plant by the use of the key, look first at the tips of the leaves. If the leaf ends in a sharp hard spine, the plant will be found in group I; if not, then look in group II. If the plant belongs to group I, then look at the leaf margins and see whether they bear hooked spines. If they do, the plant is an Agave and is one of the group of plants to which the century plant belongs. It is necessary to take the steps in determination in the order indicated or incorrect conclusions will be reached. Thus, Dasylirion has hooked spines along the margins of the leaves, but the leaves are not spiny pointed. Always settle the question under the major subdivision first before passing to questions of the next order of rank. At the end of the series of questions will be found the botanical and common names of the plant under examination or some very near relative of it. The attempt here is not so much to be technically accurate as a botanist as it is to answer the natural questions of stockmen with a degree of accuracy sufficient for their purposes.

Key to the species of yucca.

I. Leaves quite numerous in the head, narrow, one-half inch wide or generally less, with a thin, white, threadlike filament on the margin; fruit a dry pod that bursts.

1. Mature plant with a trunk from a few inches to several feet in length; flower stalk 5 to 10 feet high and much branched.....
1. *Yucca elata.* Soap weed, palmilla, ooce.

2. Mature plant usually without any perceptible trunk; stem, if any, at most only 6 or 8 inches high; leaves usually less than 2 feet long; flower stalk never over 3 or 4 feet high, usually sparingly branched.
2. *Yucca glauca.* Bear-grass (in eastern New Mexico).

II. Leaves less numerous, quite stiff, broad, 1½ to 2 inches wide, one-eighth to one fourth of an inch thick, with coarse woody threads on the margin; fruit more or less fleshy, at least when young. All species called Spanish bayonet, or dagger.

1. Mature plant with short trunk (a few inches high) or none, fruit large, 5 or 6 inches long, and fleshy.....3. *Yucca baccata.* Amole, datil, dagger.

2. Mature plant with trunk several feet in height; fruit smaller, 3 to 4 inches long, fleshy at first, but drying up without bursting.....
4. *Yucca macrocarpa.*[1] Palma, dagger.

III. Leaves intermediate in width and rigidity between the other two groups, margin not bearing a thread, but, being horny and with very minute teeth, is barely visible to the naked eye; fruit a dry pod that bursts open.....5. *Yucca rupicola.*[2]

OTHER PLANTS AVAILABLE.

Besides the above-named plants there are several others that could doubtless be used in the same manner with equally good results. The Joshua tree (*Clistoyucca arborescens*) of the Nevada-California desert region (also called *quiote* by Spanish-speaking people), *Hesperoyucca whipplei* of the California coast region, and *Hesperaloe parviflora* of Texas east of Del Rio could be used wherever they occur in sufficient abundance. *Samuela faxoniana* of the Sierra Blanca region in Texas will probably be used along with the other plants that are available there, and they are already beginning to be used. These all look like yuccas and at one time or another have been considered to be yuccas.

DISTRIBUTION AND DENSITY.

The diagrammatic map (fig. 1) shows the regions in which the more important species occur. Each has its own soil, altitude, and expo-

[1] This is the commonest species of this type in the region from Douglas, Ariz., to Marfa, Tex. *Yucca mohavensis* is another very similar species that grows in the Mojave Desert region of northwestern Arizona, southern Nevada, and southeastern California. *Yucca brevifolia* and *Yucca schottii* occur in the foothills of southern Arizona. *Yucca treculeana* occurs in the lower Rio Grande region from Laredo southward. None of these are ever very abundant, but all of them could doubtless be used for the purpose under discussion.

[2] Two other species, *Yucca thompsoniana* and *Yucca reverchoni*, occur associated with this species in the region from Haywood, Tex., north to San Angelo and eastward on rough hillsides along with sotol and sacahuista.

sure requirements, and the distribution of none of the species is uniform at any place. The map is as accurate as could be made from the data available and does not pretend to do more than indicate the general region where certain species may be expected to occur.

FIG. 1.—Diagrammatic outline map of the region where the emergency feeds considered in this bulletin are to be found: 1, Area where bear-grass (*Yucca glauca*) formerly was more or less abundant, but where the supply has been reduced by farming operations or where the growth is scattering; 2, area where bear-grass is now sufficiently abundant to render it important as feed; 3, distribution area throughout which soap weed (*Yucca elata*) occurs on sandy land but is not uniformly abundant; 4, distribution area of *Yucca rupicola* and its allies (other species of yucca, sotol, and sacahuista are also found); 5, area where lechuguilla (*Agave lechuguilla*) is most abundant (Spanish bayonet, sacahuista, and sotol are also found); 6, distribution area of sotol (*Dasylirion* spp.) and various daggers (*Yucca baccata* and *Y. macrocarpa*), as well as species of Nolina.

Soap weed (*Yucca elata*) and the bear-grass (*Yucca glauca*) of extreme eastern New Mexico and the Panhandle of Texas are practically always found on nearly level, sandy land. Occasionally they may occur sparingly upon tight soils or in a gravelly arroyo, but this is the exception. Sacahuista and the bear-grass (species of Nolina)

of southwestern New Mexico and adjacent Arizona usually grow on soil that is moderately fine, sometimes gravelly, but generally not rocky nor very sandy. In places there are large patches of it, sufficient to feed several thousand head of cattle for several months, but the total amount of this feed both in Texas and New Mexico is quite limited.

All the other species of these curious desert plants grow on rocky hillsides and slopes where the soil is coarse talus or merely piles of stones with a little soil mixed in. Lechuguilla grows only on limestone soils, but will cover hillsides, ridges, and table-lands where the limestone is but scantily covered with soil.

Only a relatively small part (at a rough estimate not over 25 per cent) of the land in the regions indicated on the map carries a crop of the species ascribed to it. Over much of the sandy land the principal plants are grasses; on the tight soils few or none of these shrubs grow; while much of the gravelly mesa area is occupied by creosote bush or black brush with only an occasional yucca. The heaviest growth of soap weed (*Yucca elata*) is to be found in the region between El Paso and Lordsburg and in the open plain between El Paso and Alamogordo.

Exact data as to the amount of feed found on an acre or a section are not available, and estimates by different men who have been cutting it vary from 3 tons per acre down. Cuttings made over 35 to 40 sections near Newman, N. Mex., yielded from 175 to 300 tons of dry leaf heads, with an average of 250 tons per section. The man who was managing this cutting estimated the dry stalks at approximately as much more in weight per section. These plants are usually shredded and fed while fresh, and the green weight is doubtless at least twice that of the dry leaves and stalks. From these figures we reach the conclusion that in regions where these plants are tolerably abundant the yield of fresh feed averaged 1½ to 2 tons per acre. Actual weights of two loads, each consisting of 38 stalks, averaged 1,340 pounds. An acre with an average stand of the growth found on the plains northeast of Las Cruces, N. Mex., in 1914 produced 85 stalks by actual count, which would weigh about 1½ tons. These figures are obtained from land where the plants of this species were of medium to large size and fairly abundant.

Yucca glauca, the bear-grass of the Staked Plain region and northward, produces from one-fourth to 1 ton per acre of dried material, according to Mr. J. E. Wallis, of Elida, N. Mex., who had cut and baled between 3,000 and 3,500 tons (dry) of it on contract. Allowing for the loss of moisture, which would be at least 50 per cent, this species in eastern New Mexico produces from 2 tons per acre on lands carrying a heavy stand down to nothing on the tight lands.

With the exception of occasional small patches of old sotol, none of the other species produce as much feed per acre as the soap weed, and

certainly none of the other species are to be found on as much land as this one.

RENEWAL AFTER CUTTING.

The soap weed (*Yucca elata*) and the bear-grass (*Yucca glauca*) both sprout readily when cut off at the ground. The best information as to the latter indicates that a new crop about as good as the original may be expected from cut-over land in about three or four years. There can be no doubt that the tall stalks of the soap weed (*Yucca elata*) are much older, however. Plants from 6 to 10 or 12 feet high are certainly 15 or 20 years old or older. Stockmen who have ridden the ranges in southern New Mexico and Arizona for many years are unanimous in estimates of this order. New heads of leaves appear at the ground, generally the next season after the old stalk is injured or killed, but it takes years to grow new tall trunks. Where they occur, these plants really constitute the desert forests, and many of them are at least 50 to 75 years old. Since the stems furnish by far the better part of the feed, it will be seen that the present method of using the plants is really but calling upon a supply of reserve feed that was not before appreciated and that its renewal is a slow process.

Experience in Texas indicates that the sotol and sacahuista do not recover when they are cut off at the root. Reports from Marathon and Sonora agree that areas which were cut over 15 years ago have not produced a new crop since and show no prospect of doing so. While actual experience is lacking with respect to the various other species mentioned here, it is highly probable that, with the exception of lechuguilla, none of them will sprout from the root when cut off. Lechuguilla sprouts readily from old stems, but the plant has a very shallow root system and it would be dug out bodily if fed, hence there would be nothing left to sprout. *Yucca baccata* has underground parts that might sprout, but it is an unimportant species, never very abundant.

Data as to the ease with which seeds will germinate are also lacking, but young seedlings are very rare in the regions where they might be expected to occur. The writer has noticed this condition many times. All the plants here considered produce abundance of seeds when they fruit, but a large proportion of the seeds are eaten in the pod by the larvæ of insects. This is especially true of the yuccas.

Under conditions that can be supplied in a greenhouse or a garden the seeds of several of the species germinate tolerably well, but such conditions do not often occur in the situations where the seeds naturally fall; hence, reproduction from seed, while possible, is but remotely probable in the open country. Moreover, if stock learn to eat the plants they will pull up the young seedlings long before they get large enough to protect themselves.

It thus appears that most of the species here listed, if used up, are not likely to return. Fortunately, the most valuable species (*Yucca elata* and *Yucca glauca*) may be expected to recover after cutting, the former slowly and the latter more rapidly, especially if the plants are not cut too close and are given an opportunity to grow.

It should be clearly understood that the supply of this emergency feed is not by any means inexhaustible; in fact, on many ranches it is scarce or very limited in amount; also that natural renewal is slow with the best species and improbable with others, while it is reasonably rapid with but one species (*Yucca glauca*). Present knowledge of the plants indicates that they should be used for emergency feed only. They should be allowed to store a supply of feed, in what might be called a natural or living silo during the favorable growing seasons, that may be used when the years of low rainfall and poor grass come—years that are sure to come when the dry part of the precipitation cycle arrives, as it does every 10 or 12 years.

QUALITY OF THE FEED.

In 1896 an analysis of sotol was published by the New Mexico Agricultural Experiment Station in Bulletin No. 17, but none of the other plants here treated were then thought of or used as feed, except as cattle occasionally chewed a few of the dry leaves.[1] In 1903 some ash analyses of three of the species listed here were published by the same station in Bulletin No. 44. In October, 1917, a press bulletin with analyses of sotol and soap weed was sent out by the same station, with comparative data for other more common feeds. On February 1, 1918, the Arizona Agricultural Experiment Station published two analyses of *Yucca elata*.[2]

The Bureau of Chemistry, United States Department of Agriculture, has been called upon to make analyses of a number of these plants at different times. The details of all are presented in Table I, all records being computed on a water-free basis. Along with these are some analyses of a few of the better known feeds, with which they may be compared. None of the ordinary feeds are exactly like these desert shrubs. They contain less water than most fresh feeds and considerably more than most dry hays. The average water content of four samples of soap weed when first prepared was 65.86, while for five samples of sotol the average water content was 60.23 per cent.

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[1] In 1898 the Texas Agricultural Experiment Station published in Bulletin No. 44 an analysis of sotol from Dull's ranch, no further data being given. This is possibly a misprint for sotol.

[2] Thornber, J. J. Soap weed or palmilla (*Yucca elata*) as emergency forage. Ariz. Agr. Exp. Sta., Timely Hints for Farmers 135, 7 p., 1 fig. 1918.

A preliminary report on some feeding experiments with soap weed and sotol is made in Press Bulletin 308 of the New Mexico Agricultural Experiment Station.

TABLE I.—*Chemical analyses of different emergency feeds, with corn stover and hay comparisons.*

Name of plant, place of collection, etc.	Date of collection.	Kind of material.	Identification.	Constitutents, water-free basis (per cent). Ash.	Crude protein.	Ether extract.	Fiber.	Nitrogen-free extract.
Yucca elata:								
Willcox, Ariz.[1]	1918	Young stems	Ariz. No. 1	5.6	7.5	1.5	16.1	69.3
Tucson, Ariz.[1]	1918	Old stems	Ariz. No. 2	9.2	3.1	.9	19.6	67.2
Las Cruces, N. Mex.[2]	Oct., 1917	Heads and leaves	N. Mex. exp. sta.	6.0	6.3	1.6	30.9	55.2
	do	Stem		6.9	4.3	1.1	24.0	63.7
	1917	Silage		6.2	6.3	2.9	37.4	47.2
	Oct., 1917	Dry leaves		6.8	2.9	2.7	38.9	48.7
Jornada Reserve [3]	May 19, 1913	Flower stalk	E. O. W. 7137	7.5	18.4	2.1	26.8	45.2
Deming, N. Mex.[3]	Aug. 24, 1910	Leaves	D. G. 10090	12.1	6.5	1.5	24.9	55.0
Willcox, Ariz.[3]	May 24, 1917	do	Ranchman	5.0	3.8	.7	19.9	70.6
Deming, N. Mex.[3]	Feb., 1918	Stem	E. O. W. 7236	9.8	6.3	2.1	25.9	55.9
		Leaves and stem	E. O. W. 7237	4.6	3.1	.7	39.4	52.2
Average of all specimens.				7.1	7.5	1.6	28.4	55.4
Yucca glauca:								
Elida, N. Mex.[3]	Mar. 30, 1918	Leaves	E. O. W. 7243	8.8	6.4	2.8	32.7	49.3
		Stems and roots		7.3	5.7	.8	25.2	61.0
Yucca macrocarpa:								
State College, N. Mex.[3]	Mar. 27, 1918	Leaves and stems	E. O. W. 7249	4.6	2.9	.6	43.1	48.8
Yucca baccata:								
Florida Mountains, N. Mex.[3]	Mar. 10, 1918	do	E. O. W. 7238	7.6	3.6	1.2	34.1	53.5
Yucca brevifolia (?):								
Near Vail, Ariz.[3]	Mar. 14, 1918	Stems	E. O. W. 7242	9.4	5.7	1.5	20.0	63.4
		Leaves		12.7	5.8	2.7	39.1	39.7
Yucca rupicola:								
Sonora, Tex.[3]	Apr. 1, 1918	Leaves and stems	E. O. W. 7245	7.3	7.2	2.3	37.3	45.9
Samuela faxoniana:								
Sierra Blanca, Tex.[3]	Apr. 5, 1918	Leaves	E. O. W. 7248	8.5	5.5	1.7	24.5	59.8
		Stem, old part		5.6	2.8	.7	33.6	57.3
		Stem, young part		7.2	13.4	1.9	11.4	66.1
Dasylirion texanum:								
Sonora, Tex.[3]	Apr. 1, 1915	Leaves	E. O. W. 7247	3.5	5.1	1.6	41.7	48.1
		Head		3.5	6.6	1.2	20.1	68.6
		Stems		7.3	17.6	2.3	26.5	46.3
Dasylirion wheeleri:								
State College, N. Mex.	1896 [4]	Head	N. Mex. exp. sta.	4.6	4.6	2.3	24.3	64.2
	Oct., 1917 [2]	do		4.2	5.4	1.9	30.7	57.8
		Dry leaves		3.1	2.3	4.4	44.4	45.8
		Unblossomed head		5.8	11.5	2.2	28.8	51.7
		Green leaves		4.5	4.6	2.4	39.6	48.9
Florida Mountains, N. Mex.[3]	Mar. 10, 1918	Head	E. O. W. 7239	4.4	4.2	1.0	29.2	61.2
Average of all analyses.				4.3	5.5	2.4	32.9	54.9
Nolina erumpens:								
Sonora, Tex.[3]	Apr. 1, 1918	Whole plant	E. O. W. 7246	5.6	8.6	2.8	41.8	41.2
Nolina microcarpa:								
Jornada Reserve [2]	Oct., 1917	Leaves	N. Mex. exp. sta.	2.9	3.7	1.5	46.6	45.3
Agave lechuguilla:								
El Paso, Tex.[3]	Mar. 26, 1918	Whole plant	E. O. W. 7244	8.9	4.4	1.7	32.5	52.5
Averages for comparison: [5]								
Corn stover (ears removed, 183 analyses).				6.4	6.5	1.8	33.9	51.4
Prairie hay (western, 42 analyses).				8.2	8.6	2.8	32.6	47.8
Alfalfa hay (250 analyses).				9.4	16.3	2.5	31.0	40.8

[1] Thornber, J. J. Soap weed or palmilla (*Yucca elata*) as emergency forage. Ariz. Agr. Exp. Sta., Timely Hints for Farmers 135, 7 p., 1 fig. 1918.

[2] New Mexico Experiment Station, Press Bulletin 301.

[3] Analysis made in the Cattle Feeds and Grain Investigations Laboratory of the U. S. Bureau of Chemistry, under the direction of Mr. G. L. Bidwell.

[4] Goss, Arthur. Principles of stock feeding and some New Mexico feeding stuffs. N. Mex. Agr. Exp. Sta. Bul. 17, p. 21-54. 1895.

[5] Henry, W. A., and Morrison, F. B. Feeds and Feeding. . . . ed. 16, p. 633-646. Madison, Wis., 1916.

The analyses of soap weed and sotol show that the food value of the different parts of the plant varies and that the food content of the same parts of different plants also varies. This is as was to be expected. The growing parts of the plant would naturally have less fiber and more protein because they are growing, and the leaf bases and young stems would also show relatively higher food content because of their use by the plant for storage of such material against the flowering time. A change in the percentage of one constituent of necessity affects the figures for all the rest.

The average values for the 13 analyses of soap weed and 6 analyses of sotol are more nearly like those of western prairie hay (average of 42 analyses) than any other kind of feed usually fed, though they also approximate those of corn stover.

There was considerable discussion among those interested about the relative values of this feed and alfalfa hay. Assuming that they are equally digestible and that there is nothing deleterious in the soap weed, the figures given in Table I show something of the relative merits of the two feeds. From these figures alone we see that for perfectly dry material the amount of protein in 100 pounds of alfalfa is about twice as much as that in the soap weed and that the fat-carbohydrate percentages are higher in the soap weed. Both these conditions indicate higher feed value in the alfalfa. In addition to these is the condition in which the material is fed. Alfalfa is fed when air dry, and 100 pounds of hay furnishes about 93 pounds of dry matter of which between 8 and 9 pounds is crude protein. Soap weed is fed fresh cut and 100 pounds of the feed contains only about 35 pounds of dry matter, of which about 2½ pounds is protein. Thus, for every 100 pounds of alfalfa fed, an animal gets nearly three times as much feed which is at the same time twice as good feed as when he is fed 100 pounds of chopped yucca. This should answer the question very emphatically in favor of alfalfa, but at the same time it should in no way detract from the value of the soap weed as an emergency feed.

It must be clearly recognized that the soap weed and all such feeds are of low feed value and, taken alone, are feeds of very wide nutritive ratios. In other words, the amount of tissue-building food material (protein) found in these feeds constitutes only a small proportion of the total amount of the material fed, and is also small in amount when compared with the other food materials (fats and carbohydrates) present in such feeds. The fresh, moist condition of the feed when fed is advantageous, and under certain conditions it would no doubt be worth while to feed a certain amount of such material to stock on dry feed. However, under most conditions the expense of preparing the feed is such that it is not warranted unless no other feed is available at a less cost.

The distances which feeds produced on cultivated land must be transported compel the stockmen who use such feeds to seek those that are highly concentrated. The cottonseed products, meal and cake, are such feeds, and they have high protein content. They are to be had in the region and with a shorter haul than any feeds of equal value, with the exception of alfalfa. Hay and forage crops are not concentrated, and they are correspondingly hard to transport. But while the cottonseed products may be safely fed in small quantities, it is necessary that they be accompanied by sufficient roughage to give the requisite bulk and balance to the ration. They can not be fed alone for a long time or in very large quantities without serious detriment to the stock. If the dry range feed is practically all gone, the needed roughage may be supplied by soap weed or some other of the plants listed here if the plants grow on the ranch in sufficient quantity to make it possible to shred them.

But it is argued that without knowing the digestion coefficient it is not possible to tell a great deal about the value of feed from the ordinary chemical analysis.[1] From the practical standpoint, however, the answers obtained by feeders are conclusive as far as they go, though the optimistic stockman may easily overstate the results he has obtained. There is no doubt that the use of this feed saved thousands of cattle in the region in 1917. One man who was feeding 2,800 head of all kinds of cattle, from coming yearlings to cows with young calves, assured the writer that his losses had been kept down to approximately 7 per cent,[2] and that they would doubtless have been as high as 30 per cent without this feed, though he was feeding cottonseed cake besides.

One man who was feeding 400 head of cows and calves said that 13 of the cows were so weak when feeding was begun that they had to be helped up every time they lay down. They had been fed nothing else but chopped soap weed for six weeks and are now strong enough to take care of themselves.

One other extreme was that of a young cow found down and unable to get up. She would have died of thirst in a few days. The men hauled her to the watering place on the float with which they were hauling the soap weed and commenced to feed her. By using the chopped feed and a little cottonseed meal she was saved and has since dropped a calf which is alive and well.

There is no question that the chopped soap weed, sotol, bear-grass, or sacahuista will keep cattle and sheep from starving if fed in suffi-

[1] The need of this digestion coefficient is thoroughly appreciated, and steps have already been taken to obtain this factor for both soap weed and sotol at the New Mexico Agricultural Experiment Station, which is especially equipped for this work.

[2] It is customary to figure on an average loss of about 10 per cent on open ranges.

cient quantity, because it has been done; and under certain circumstances like the present, when the saving and producing of meat is so vitally important to the whole world, the mere possibility of keeping stock from dying during the short period of feed scarcity assumes an importance out of all proportion to the possible financial loss involved. It was the appreciation of the necessity of saving not only all the meat animals that would have died but especially the breeding stock which are to furnish the next beef crop that made not only the stockmen but the makers of the chopping machines so persistent in their effective efforts. Stockmen of long experience in the arid Southwest know that it is the series of dry years that puts them out of business. They know that the dry years will be followed by wet ones and that the calf crops when there is good feed will more than pay the expense of saving the breeding herd in the dry years, if it can be done. They also know that if the breeding herd is lost there will be no calf crop, no matter how good the feed may be later; hence, the very great importance of feed on their own ranges, which may be made available to the stock at small expense and with a little work.

QUANTITY FED.

This bulletin contains no records of weights except in the case of the two wagonloads already mentioned. The other figures given rest upon the judgment of the men doing the hauling, whose estimates, however, are reasonably accurate. There was of course no uniformity of practice among the users of the feed, and the opinions as to the necessary amounts to feed ranged from 10 to 40 pounds of fresh-chopped feed per day for a mature animal. In practice, however, no one whose record was obtained fed more than 30 pounds per head per day, and over half of them fed less than 18 pounds per head per day. The feed for weaned calves and coming yearlings was 6 or 7 pounds per head and for mature animals about 18 to 20 pounds per head per day. The average feed for 11,373 head of all classes was 14 pounds per head of chopped soap weed per day.

A feed of 15 pounds of freshly chopped soap weed (*Yucca elata*) contains a little more than 5 pounds of dry matter, of which about 0.4 of a pound is crude protein, less than 0.1 of a pound is ether extract (usually called fat), 1.4 pounds is crude fiber, and 2.8 pounds is nitrogen-free extract (usually called carbohydrates). A feed of 15 pounds of average alfalfa hay would contain nearly 14 pounds of dry matter, containing 2.23 pounds of crude protein, 0.34 pound of ether extract, 4.23 pounds of fiber, and 5.60 pounds of nitrogen-free extract.

It will be seen from these figures that there is in alfalfa hay over 2½ times as much total dry matter, over five times as much crude

protein, more than four times as much ether extract, and twice as much nitrogen-free extract as is to be found in an equal weight of freshly chopped soap weed. In other words, 15 to 20 pounds of freshly chopped soap weed is a daily ration that will barely sustain life in the animal, and it needs some concentrate that has a large percentage of protein to go with it in order to make the animal grow or improve in condition.

MECHANICAL CONDITION OF THE FEED.

The soap weed when prepared by any of the machines is cut into slices one-half to three-fourths of an inch thick and 2 or 3 inches each way or is torn into small shreddy pieces an inch or two long. The fibers, which are very numerous in both leaves and stems, are cut in pieces never more than 1 or 2 inches long, except that the leaves are frequently torn off the head and but partly chopped into pieces. It is the usual practice to cut down the stalks, haul them to the choppers, shred, and feed all during the same day. It is not necessary that this practice should be followed, as the stems retain their moisture a long time. It was impossible by any ordinary inspection to tell much difference in the moisture content of shredded material from fresh stalks and from those that had been cut a month before shredding.

The material is quite wet when freshly shredded, is noticeably sweet to the taste (with a distinct bitter aftertaste), and is in such shape that cattle or sheep can eat it readily. Cattle learn to eat it in a very short time and seem to like it. They will go ahead of the wagons to the feeding grounds, and calves soon learn to slip through gates to get to the machine when it is at work.[1] Very little of the soap weed has been fed to sheep so far, though it is a common practice to feed sotol to them in Texas. Certain advantages that have not yet been well tried are doubtless to be gained by the use of these yuccas for sheep, upon which definite data are wanting.

Most of the men who are using this feed burn off the dead leaves before cutting the stalks, leaving only the tuft of green leaves at the top. In one instance, where it was necessary to haul the stalks more than 2 miles to the feeding place, the herd had been divided into two parts. One part, composed of the stronger animals that could easily walk to and from the water, was held on the ground where the soap weed was growing. The green tops (leaves) of the plants were cut off with the axes and left scattered upon the ground for these animals to eat. The stems, which look like so many sticks of wood, were hauled to the corral and shredded for the other part of the herd.

[1] The chopped or shredded feed sours and heats very quickly if left in a pile. Small piles left lying for some days ultimately mildew and spoil. Cattle eat the soured material freely.

This method avoids the necessity of handling and hauling a large part of the feed and makes the work of handling and shredding the remainder easier. It has given satisfactory results. It is probably not altogether wise to burn off the dry leaves, as they contain some feed value that should not be wasted, but they make the shredding operation much more difficult, and the feed value in the dry leaves may not be worth the additional labor [1] necessary to pass them through the machine.

In most cases additional feed, usually cottonseed cake, was being fed to the animals. This is as it should be, since the shredded feed is nothing but a low grade of roughness comparable to corn stover (ears removed) or range-grass hay.

STOCK LOSSES FROM USING THIS FEED.

A particular effort was made to learn whether or not the chopped feed was in any way responsible for losses of any kind among the stock fed. Scouring was reported from a few herds, but it was never of any importance and was overcome by adding dry feed to the ration. In a few cases this result was obtained by grinding up the old dead leaves of the plants with the rest of the feed, instead of burning them off.

A few cases of bloating were reported when animals had been fed quite heavily with the chopped soap weed. No cases of abortion were found, though all the feeders were asked about it. Some cases of impaction were found and some choking, but in all cases of loss from either of these causes the feed was hand chopped, and the trouble arose from the mechanical condition of the feed rather than from any other cause. One source of loss was the chilling which occurred at night when the temperature fell. Cattle weak and poor from starvation would lie down and get chilled and never get up. With one herd the men stayed with the animals on one cold night and kept them moving about to prevent losses of this kind. Such losses arose from lack of feed instead of the use of this kind.

The total losses directly attributable to properly shredded soap weed were negligible.

COST OF FEEDING SOAP WEED.

In getting together the material for this bulletin the writer interviewed many different men who had fed or were feeding sotol, sacahuista, bear-grass, or soap weed. He saw all of the various kinds of machines at work on ranches. He obtained 13 complete reports from men who were chopping soap weed to feed to cattle in Arizona, New

[1] Some of the men who were chopping the soap weed by hand cut the stalks and piled them before burning off the dead leaves. They found that the heat tended to cook and soften the stems, thereby making the work of chopping easier.

Mexico, and Texas. The number of cattle that these 13 outfits were feeding aggregated almost 10,000 head. The details of investment and expense connected with these outfits are shown in Table II.

TABLE II.—*Expenses of maintenance of outfits for shredding soap weed and cost of feeding the prepared product.*

State and record.	Kind of machine.[a]	Engine.	Investment.				Expenses per month.						Number of animals fed.	Cost per month per animal.
			Chopper.	Engine.	Teams, etc.	Total.	Wages.	Board.	Horse feed.	Fuel and oil.	Repairs and depreciation.	Interest.		
New Mexico:														
No. 1	A	10 H. P.	$280	$275	$750	$1,305	$210	$105	$60	$40	$26	$11	1,040	$0.44
Texas:														
No. 2	B	14 H. P.	618	600	1,600	2,818	405	250	60	75	44	24	2,000	.43
No. 3	B	12 H. P.	600	545	400	1,545	205	75	25	6	13	13	400	.84
No. 4	C	10 H. P.	104	300	500	904	135	90	30	9	8	8	600	.47
No. 5	B	14 H. P.	615	433	260	1,308	30	10	10	3	11	11	800	[b].10
New Mexico:														
No. 6	B	14 H. P.	600	600	1,000	2,200	40	14	6	9	18	15	200	.51
Arizona:														
No. 7	B	12 H. P.	560	300	640	1,500	240	175	60	30	13	13	450	1.18
No. 8	D	7 H. P.	150	350	250	750	200	66	20	26	6	6	383	.85
No. 9	Silage cutter.	12 H. P.	75	250	400	725	50	20	30	5	6	6	200	.59
New Mexico:														
No. 10	A	12 H. P.	375	500	1,200	2,075	295	105	165	75	15	15	1,200	.56
No. 11	B		530	267	925	1,722	160	60	105	62	14	14	1,600	.26
No. 12	A		360	385	450	1,195	120	75	90	7	10	10	600	.52
No. 13	D	Automobile.	155	150	450	755	60	30	76	101	8	6	200	[c]1.40
Total			5,007	4,970	8,825	18,802	2,150	1,075	337	448	192	154	9,673	
Average			385	382	679	1,447	165	83	57	34	15	12		.49

[a] The Office of Forage-Crop Investigations of the Bureau of Plant Industry will be glad to answer any inquiries regarding machines and their manufacturers.

[b] This figure is quite small because the animals were young and were being fed only 5 or 6 pounds of chopped feed per day.

[c] This figure is very large on account of the character of fuel it was necessary to use in the engine, which was bought at a very high price. Most of the other gas engines used distillate. This engine had to have gasoline. These figures correct each other in the average.

It will be seen that depreciation and interest charges have been made against the entire value of the investment that is in any way used for the preparation or feeding of the soap weed. Included in this investment is the value of teams, wagons, and harness, as well as saddle horses, and sometimes gas engines, that are normal equipment of the ranch and which are used for other purposes. To the extent that they are used for other purposes during the period when feeding is being done, the charge becomes an overcharge to the feeding cost and the results obtained are to that extent in excess of the truth. It is safe to say that the average cost of 50 cents per head per month for feeding the soap weed is a fair average upon which to estimate where the haul is not too great. And no stockman will hesitate to incur such an expense to save his stock. As will be seen, all the various kinds of machines in use are represented. There was no attempt to select any special kind. Every user of any kind of machine from whom the writer could get definite information was

asked for the results of his experience. Thirty more or less complete records were obtained in this way, and those which gave conclusive evidence with respect to machine-chopped soap weed are included in Table II. A number of them recounted the experience of men who were cutting sotol or bear-grass by hand.

There is absolute unanimity of opinion that soap weed, sotol, bear-grass of either kind, or sacahuista if fed in sufficient quantity and given to the stock before they get very weak from starvation will save them in every instance.

Stockmen of the region all recognize the advantage of the machines. One man who had used one of them for some time, in conversation with a neighbor, asked if his friend had a machine. The latter replied that he had not yet bought one, and the experienced man said, "Well, buy two."

Records of the sale of 80 machines up to March 31, 1918, were obtained from the makers, and orders for several more had already been received.

The total number of stock being fed one or another of these feeds in 1918 whose owners were interviewed by the writer was 16,298 besides 885 that had been fed hand-chopped material in 1917. It was the general opinion of the men who were feeding that from 75 to 90 per cent of these weaker animals would have died if they had not been fed. The animals that were being fed constituted from 30 to 100 per cent of the different herds to which they belonged. Almost all of these men were feeding some cottonseed cake or meal (they expressed various differences of opinion as to which is better) if they could get it. But several said their stock were already beginning to go down on cake alone when they commenced feeding soap weed, and the animals at once showed improvement.

The additional expense of feeding cake or meal may be easily calculated from the amount fed per day and the price of the feed at the ranch. This price varied this year from 2½ to 3¾ cents per pound, and the amount fed varies from one-half pound for young stock to 2 pounds for mature breeding animals, with an average of about 1 pound per head per day.

IMPORTANCE OF EMERGENCY FEEDS.

The best measure of the importance of this subject is shown by the numbers of animals involved. These numbers give some conception of the possible losses that may be avoided by the feeding. The only figures available for Arizona and New Mexico are the United States Department of Agriculture reports of range cattle and sheep for the various counties where these feeds occur. (See Table III.) These figures are furnished by the field agents of the Bureau of Crop Estimates.[1]

[1] Mr. L. M. Harrison for Arizona and Dr. R. F. Hare for New Mexico.

The figures for Texas given in Table III are taken from the Report of the State Comptroller for 1916, the latest published. It is not intended to suggest that these emergency feeds are of equal importance to all of these stock, and in the present state of our knowledge it is impossible to give even an estimate of what percentage of the total number of animals here listed have been or are likely to be in any way affected. It is safe to say that a large percentage of cattle that otherwise would have died were saved by this means in the following counties: Arizona—Cochise and Greenlee; New Mexico—Grant, Luna, Dona Ana, Otero, and Eddy; Texas—El Paso, Culberson, Jeff Davis, Presidio, Reeves, Pecos, Brewster, and Terrell. It is certainly true that the actual total number of animals saved is large, even though the percentage of the total number of animals in the region is not large. In the past it has been not uncommon for cattlemen in this region to suffer losses amounting to 30 per cent or even 40 per cent of their cattle in years of extreme drought, such as the present period is. If the use of these emergency feeds results in reducing the losses to nothing more than normal. thousands of head of stock will have been saved.

TABLE III.—*Estimated number of cattle and sheep in certain counties of Arizona, New Mexico, and Texas.*

Counties.	Cattle.	Sheep.	Counties.	Cattle.	Sheep.
Arizona, 1917:			Texas—Continued.		
Cochise	114,000	9,000	Presidio	41,934	2,510
Greenlee	38,000	.....	Brewster	63,809	7,600
Graham	83,000	.....	Reeves	29,369	715
Santa Cruz	29,000	.....	Loving	4,623	.....
Pima	71,000	.....	Winkler	11,959	.....
Pinal	56,000	8,000	Pecos	71,366	66,525
			Terrell	18,826	67,406
Total	391,000	17,000	Valverde	33,232	227,695
			Bailey	22,337	.....
New Mexico, Jan. 1, 1918:			Cochran	6,349	1,975
Grant	140,000	6,000	Hockley	18,223	.....
Luna	40,000	20,000	Yoakum	16,322	5
Sierra	50,000	2,000	Terry	18,879	209
Dona Ana	30,000	8,000	Dawson	20,000	1,000
Socorro	150,000	440,000	Andrews	27,788	.....
Otero	40,000	25,000	Martin	55,493	27
Lincoln	50,000	180,000	Ector	19,061	62
Eddy	70,000	70,000	Midland	29,938	51
Chaves	90,000	200,000	Crane	10,645	.....
Roosevelt	60,000	5,000	Upton	23,776	4,758
Curry	30,000	1,000	Reagan	17,940	15,630
Quay	50,000	50,000	Crockett	52,871	90,825
			Schleicher	40,907	50,478
Total	800,000	1,007,000	Sutton	42,510	142,012
			Edwards	39,860	90,711
Texas, 1917:			Kinney	26,799	34,311
El Paso	45,312	1,335			
Culberson	34,917	4,700	Total	896,812	810,540
Jeff Davis	51,876	.....			

ARGUMENT FOR FEEDING RANGE STOCK.

There are no more loyal citizens in our Nation than the western stockmen. Nothing is needed to stimulate their patriotic endeavors except to point out clearly to them the relation of their business to

the war, and most of them already understand it perfectly. The United States Food Administration has blazoned its slogan "Food will win the war" from one ocean to the other and from Canada to Mexico; but most people think only of the crop farmer as the producer of food, although meat is one of the most important of the foods. No higher kind of loyalty and service can be rendered by stockmen than the use of their experience, equipment, and effort in the production of the maximum quantity of this necessary kind of food. Soldiers can not fight without an abundance of strong food, and food can not be purchased for them, no matter how much money we have, if it is not produced in sufficient quantities. Every cow that dies is herself just so much meat lost, and with her death there ends a continuing stream of meat-producing animals which can not be started flowing again. Hence, it is vitally important to save all animals, but especially the breeding stock.

But while reasons of this higher type will appeal to stockmen in general, they are by no means the only arguments in favor of saving cows. Experience has shown that it is ordinarily good management to feed range stock a small amount of concentrated feed during ordinary years, and especially in seasons of drought and consequent poor range feeds.

Suppose that in any given year, without additional feed, the loss of breeding cows on the range is 10 per cent, or that out of every 100 cows, 10 will die. Suppose the rate of increase is 70 per cent of the breeding cows.[1] If no feeding is done, at the end of the year, out of each 100 cows there will be left 90, and they will have 63 calves. If they are fed well enough to reduce the losses to 2 per cent, there will be 98 cows left, and they will produce 68 calves. If the cost of the feeding has been the value of 8 cows, the stockman has 5 more calves per 100 cows by the one method than by the other. If the cost has been less than that amount, the difference in his favor is greater. Besides this, his animals are all in better condition. If the calves have been weaned at six months and fed a small amount of concentrates and the breeding cows and bulls have also been fed, all of the stock are in better condition, the calves bring a better price as yearlings, and the next year's crop is larger and of better quality, because of the physical condition of the breeding stock and also because there will be eight more cows per hundred left in the herd. Stockmen all agree that animals that have once been fed are much tamer and more easily handled than before, and that this is an important factor in all work done with them thereafter.

All of the above applies to the ordinary or usual conditions. In proportion as the rainfall of any season is below the average, the feed for the next year is bound to be reduced, and after two seasons of

[1] This is the average for one well-managed ranch for a period of 12 years, and it is certainly above the average for the ordinary range.

diminished production the feed left on the range is not only scanty, but is of the very poorest quality. If the range is fully stocked when the dry years come (as is usually the case, since the previous years have generally been years of more than average production), it is absolutely necessary to do one of three things—reduce the number of animals on the area, feed them some kind of material they can not get for themselves, or let some of them die of starvation. The amount of reduction necessary is very difficult to determine, and the necessity for doing it usually is recognized only after the stock commence to go off in quality and therefore in selling value. Feeding the stock maintains or improves their quality and numbers, and prevents forced selling, but cuts into the net receipts. However, it is much the least of the three evils, and while the expense involved is nearly always greater the longer and more widely distributed the drought may be, the increased selling prices which usually accompany such conditions compensate more or less for the increase in expense

Range stockmen who can obtain at a reasonable price a concentrated feed like cottonseed cake that contains a high percentage of protein, and who have their ranges fenced, have been feeding for a number of years. The principal factor which has prevented New Mexico and Arizona cattlemen from following in the way others have led is their lack of legal control of their range lands. It is a common custom in the open-range country to water all the animals that come to the watering places. But it would be very difficult to feed one's own stock and keep stock of other brands away from the feed as long as they run together on the range. In particular cases stock of different owners have been and are now being fed together just as they are now watered, but adjustments are hard to make and are apt to lead to misunderstandings, especially where tempers and confidence are already strained.

No one advance step could be taken which would benefit this business so much as some legislation that would give the southwestern stockman legalized control of the land he uses and thereby allow him to fence his range.

SUMMARY AND CONCLUSIONS.

It has been demonstrated by trial on a large scale that several desert shrubs, some of which have not been used until recently, are valuable emergency feed for range cattle and sheep in times of extreme drought, if properly prepared.

The preparation consists of chopping or shredding the stems and leaves of these plants by machines that have recently been designed and produced. Hand chopping of the material is possible, but it is slow and laborious and the product is not very satisfactory. The machine-chopped material is satisfactory in every way.

Several different kinds of machines are now being manufactured, any one of which will do the work required and can be handled readily by the kind of labor available on the average stock ranch.

The cost of the necessary equipment, from $1,000 to $2,500 (depending on the number of animals to be fed), is such that it is within the reach of the average stockman who needs it. A much smaller initial expense is usually sufficient, since most of the ranches are already supplied with one or more gas engines and all the horses and wagons necessary for the work.

The chemical analyses of these feeds and the experience of the men who are feeding them agree in showing that the feed is of low nutritive value and is to be considered as roughage, comparable to range-grass hay. If fed alone it may be expected to keep stock from starving; if fed with concentrates a properly balanced ration may be worked out.

The customary practice among users of the feed is to give young stock 6 to 12 pounds of chopped soap weed a day with one-half to three-fourths of a pound of cottonseed cake or meal. Mature stock are given 20 to 40 pounds of soap weed and 1 to 2 pounds of cottonseed cake per day. Of the chopped feed alone, 20 to 25 pounds per day will save stock from dying. With a pound of cottonseed cake in addition, a fairly well-balanced living ration is produced.

Only two of the species of the plants here discussed may be expected to renew themselves if cut off. The bear-grass of the New Mexico–Texas Plains region (*Yucca glauca*) will produce a new crop in three or four years. Soap weed (*Yucca elata*) will doubtless need 10 to 15 years to produce another crop equal to that now being removed. All the other species will probably be destroyed if cut off at the ground for feeding purposes, unless steps are taken to insure a new crop.

The average cost of feeding about 20 pounds of chopped soap weed per animal is about 50 cents a month, or $1\frac{2}{3}$ cents a day. With the addition of cottonseed cake, when worth $67 per ton at the ranch, stock can be kept in good condition and sometimes improved for about 5 cents per day per animal at the present prevailing prices of labor, fuel, oil, etc.

The argument for the emergency feeding of range stock rests primarily upon a basis of war-time need of meat, but it can easily be shown that it is a perfectly good economic policy. Stockmen in the region under consideration would doubtless have acted much as they have, with respect to this method of saving their stock, even if the war-time incentive had not existed; but they would probably have adopted this method much more slowly. Such delay would have resulted in much greater losses of animals and income than will now

be sustained, and war-time selling prices will tend to compensate for such expenses as may result from the policy adopted.

These emergency feed plants are all well adapted to the climatic and soil conditions of the region in which they grow and are capable of withstanding the most prolonged droughts which occur in that region. They grow vigorously during favorable seasons and less so during unfavorable ones, but as long as they grow they are storing up food in what is in reality a living, self-filling silo. There is reason to believe that the feed is in its best condition at the very time that it is most needed, i. e., in the period of excessive drought. The feed is fresh and may be used at any time. The "silo" will refill itself in many cases if given time. Careful consideration of the subject leads to the judgment that these plants should be used only for emergency conditions, and that they should be allowed to grow during favorable seasons.

YOU WILL REALIZE, as I think statesmen on both sides of the water realize, that the culminating crisis of the struggle has come and that the achievements of this year on the one side or the other must determine the issue. It has turned out that the forces that fight for freedom, the freedom of man, all over the world as well as our own, depend upon us in an extraordinary and unexpected degree for sustenance, for the supply of the materials by which men are to live and to fight, and it will be our glory when the war is over that we have supplied those materials and supplied them abundantly, and it will be all the more glory because in supplying them we have made our supreme effort and sacrifice.—*From President Wilson's Message to the Farmers' Conference at Urbana, Ill., January 31, 1918.*

IN THE FIELD OF AGRICULTURE we have agencies and instrumentalities, fortunately, such as no other Government in the world can show. The Department of Agriculture is undoubtedly the greatest practical and scientific agricultural organization in the world. Its total annual budget of $46,000,000 has been increased during the last four years more than 72 per cent. It has a staff of 18,000, including a large number of highly trained experts, and alongside of it stand the unique land-grant colleges, which are without example elsewhere, and the 69 State and Federal experiment stations. These colleges and experiment stations have a total endowment of plant and equipment of $172,000,000 and an income of more than $35,000,000, with 10,271 teachers, a resident student body of 125,000, and a vast additional number receiving instruction at their homes. County agents, joint officers of the Department of Agriculture and of the colleges, are everywhere cooperating with the farmers and assisting them. The number of extension workers under the Smith-Lever act and under the recent emergency legislation has grown to 5,500 men and women working regularly in the various communities and taking to the farmer the latest scientific and practical information. Alongside these great public agencies stand the very effective voluntary organizations among the farmers themselves, which are more and more learning the best methods of cooperation and the best methods of putting to practical use the assistance derived from governmental sources. The banking legislation of the last two or three years has given the farmers access to the great lendable capital of the country, and it has become the duty both of the men in charge of the Federal reserve banking system and of the farm-loan banking system to see to it that the farmers obtain the credit, both short and long term, to which they are entitled not only, but which it is imperatively necessary should be extended to them, if the present tasks of the country are to be adequately performed. Both by direct purchase of nitrates and by the establishment of plants to produce nitrates, the Government is doing its utmost to assist in the problem of fertilization. The Department of Agriculture and other agencies are actively assisting the farmers to locate, safeguard, and secure at cost an adequate supply of sound seed.—*From President Wilson's Message to the Farmers' Conference at Urbana, Ill., January 31, 1918.*

THE FARMERS OF THIS COUNTRY are as efficient as any other farmers in the world. They do not produce more per acre than the farmers in Europe. It is not necessary that they should do so. It would perhaps be bad economy for them to attempt it. But they do produce by two to three or four times more per man, per unit of labor and capital, than the farmers of any European country. They are more alert and use more labor-saving devices than any other farmers in the world. And their response to the demands of the present emergency has been in every way remarkable. Last spring their planting exceeded by 12,000,000 acres the largest planting of any previous year, and the yields from the crops were record-breaking yields. In the fall of 1917 a wheat acreage of 42,170,000 was planted, which was 1,000,000 larger than for any preceding year, 3,000,000 greater than the next largest, and 7,000,000 greater than the preceding five-year average.

But I ought to say to you that it is not only necessary that these achievements should be repeated, but that they should be exceeded. I know what this advice involves. It involves not only labor but sacrifice, the painstaking application of every bit of scientific knowledge and every tested practice that is available. It means the utmost economy, even to the point where the pinch comes. It means the kind of concentration and self-sacrifice which is involved in the field of battle itself, where the object always looms greater than the individual. And yet the Government will help, and help in every way that is possible.—*From President Wilson's Message to the Farmers' Conference at Urbana, Ill., January 31, 1918.*"

IT WAS FARMERS from whom came the first shots at Lexington, that set aflame the Revolution that made America free. I hope and believe that the farmers of America will willingly and conspicuously stand by to win this war also. The toil, the intelligence, the energy, the foresight, the self-sacrifice, and devotion of the farmers of America will, I believe, bring to a triumphant conclusion this great last war for the emancipation of men from the control of arbitrary government and the selfishness of class legislation and control, and then, when the end has come, we may look each other in the face and be glad that we are Americans and have had the privilege to play such a part.—*From President Wilson's Message to the Farmers' Conference at Urbana, Ill., January 31, 1918.*

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